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ENHANCED ROOT YIELD AND Β-CAROTENE CONTENT OF ORANGE FLESHED SWEETPOTATO USING INTEGRATED NUTRIENT MANAGEMENT

[1*]Anedo, E.O., [2]Asawalam, D.O., [1]Njoku, J.C., [1]Adesina, B.A., [1]Okoye, A.C. and [1]Nwogha, J.S
[1]National Root Crops Research Institute Umudike, P.M.B.7006 Umuahia Abia state
[2]Department of Soil science and Meteorology Michael Okpara University of Agriculture Umudike Abia State.
*Email: emmaanedo@gmail.com

ABSTRACT
This study was conducted in 2014 and 2015planting season at the Research farm of National Root Crops Research Institute Umudike, southeastern, Nigeria to determine the effect of integrated nutrient management on root yield and total carotenoid content of orange fleshed sweetpotato. The experiment was a 5x4 factorial laid out in randomized complete block design (RCBD). The treatment comprises of five levels of composite manure (Pig manure, cowdung and poultry manure) applied at the rate of 0, 2, 4, 6 and 8t/ha and mineral fertilizer (NPK 15:15:15) applied at the rate of 0, 200, 400 and 600kg/ha. Combined application of mineral fertilizer and composite manure significantly ($p<0.05$) increased the total and marketable root yield of orange fleshed sweetpotato. Application of 4t/ha composite manure + 400kg/ha NPK gave the highest mean root yield of 15.90t/ha relative to control. The β-content increased generally with increasing rate of the treatment combinations with application of 8t/ha composite manure + 200kg/ha NPK giving the highest β-carotenoid content of 733.2µg/g. Results of the regression analysis showed that Organic matter, total nitrogen, available phosphorous, effective cation exchange capacity and percentage base saturation are the major soil chemical properties that contributes to increase in the β-carotene content of the orange fleshed sweetpotato. From the results obtained, application of 4t/ha composite manure + 400kg/ha NPK is recommended for good root yield while application of 8t/ha composite manure + 200kg NPK is recommended for farmers who wish to improve the carotenoid content of orange fleshed sweetpotato.

Keywords: Composite manure, mineral fertilizer, root yield, orange fleshed sweetpotato and carotenoid

Introduction

The orange-fleshed sweet potato varieties are gaining great attention as a means of reducing common health related problems in low income communities associated with vitamin A deficiency. The varieties are believed to be the least expensive source of dietary vitamin A available to poor families (Laure *et al*, 2013). This is due to their high nutritive value of beta-carotene content, a precursor to vitamin A synthesis (Ukpabi *et al*, 2012). The high yielding orange-fleshed sweet potato varieties are fertilizer responsive (Nedunchezhiyan *et al*, 2010). Applications of inorganic fertilizers have been reported to increase root yield (Nedunchezhiyan and Reddy, 2002). But hampers the quality of sweet potato (Nedunchezhiyan *et al*, 2003). Better sweet potato root quality was observed at optimum amount of nitrogen supply especially through organic sources (Nedunchezhiyan *et al*, 2003). B-carotene content of the root though governed by the genetic factor, Agronomic factors like source and quantity of nutrients significantly influenced the content (Nedunchezhiyan, *et al*, 2010). According to Nedunchezhiyan and Reddy, (2002), sweet potato gets nutrients throughout the growing period when there is integrated use of inorganic (immediately available) and organic (slow mineralisation) source of nutrients which leads to higher yield attributes. However, there is limited information on the integrated use of Composite manure (poultry manure, Cowdung and swine waste) together with mineral fertilizer on improving the root yield and total carotenoid content of orange fleshed sweetpotato in southeastern Nigeria. Therefore, the objective of this study is to determine the effect of integrated nutrient management on root yield and β-carotene content of orangefleshed sweetpotato

Materials and Methods

The experiment was conducted at the Research farm of National Root Crops Research Institute Umudike, southeastern, Nigeria in 2014 and 2015 planting seasons. The experiment was a 5x4 factorial laid out in Randomized Complete Block Design (RCBD). The plot size measures 3m x 3m with 0.5m separating the plots and 1m separating the replicates. Materials for the experiment comprises of Composite manure (cowdung, poultry droppings, pig manure) and mineral fertilizer (NPK 15:15:15). Equal weights (72kg each) of the three animal manures were bulked together and applied to the plots at the rate of 2, 4, 6 and 8t/ha with 0t/ha as control. They were factorially combined with 0, 200, 400 and 600kg/ha of NPK 15:15:15 giving a total of 20 treatment combinations replicated three times. The animal manures were applied to the plots one week before planting. While mineral fertilizer was applied at 4 weeks after planting. The test crop orange fleshed sweet potato variety Umuspo 1 (King J) was obtained from sweetpotato programme of NRCRI, Umudike. All agronomic practices recommended for sweetpotato production were carried out.The storage roots w ere harvested at 16 weeks after planting and grad ed based on weights as Marketable roots (>100g), unmarketable roots(<100g)(Levett,1993).The total root yield was also computed. The carotenoid analysis was done using the method described by Rodriguez-Amaya and Kimura (2004) and calculated using the formula:

Total carotenoid μg/g = {[$A^{1\%}$ x volume (ml) x 104 x DF]/ [A12 1cm x Weight of sample]}

Where:

A: = Absorbance

Volume: Total volume of extract

$A^{1\%}$ 1cm: Absorbance coefficient of β- Carotene in petroleum ether (2592).

DF = dilution factor and multiplied by 100 to get the carotenoid content in μg/100g. Statistical analysis of data generated was performed using Genstat Discovery Edition using the procedures of factorial experiments. Significant means were separated using Fishers least significant difference (F-LSD) at 5% level probability. Ordinary least square regression was used to determine the relationship between selected soil chemical properties and β-carotene content of orangefleshed sweetpotato

Results and Discussion

Effect of Integrated Nutrient Management on the total root yield orange fleshed sweet potato

The result of the effect of integrated nutrient management on the total root yield of orange fleshed sweet potato is presented in table 3. The results obtained showed that the interaction of composite manure and mineral fertilizer significantly ($p<0.05$) increased the total root yield of orange fleshed sweet potato relative to the control. The highest mean root yield of 15.90t/ha was recorded with the application of 4t/ha composite manure + 400kg NPK. The higher root yield obtained with the application of composite manure and mineral fertilizer in this study might be as a result of improvement in the physicochemical properties of the soil which leads to the release of nutrients for crop uptake. Similar results were reported by Agyarkor *et al*, (2014) with incorporation of organic manure and NPK on sweetpotato yield; Akinmutimi, (2014) with application of Cocoa pod husk ash and NPK on the yield of sweetpotato; Onunka *et al*, (2012) with application of organic and inorganic manures on root yield of sweet potato; Asawalam and Onwudiwe, (2011) with complementary use of Cow dung and mineral fertilizer on sweet potato; Yeng *et al* (2012) with integrated application of chicken manure and inorganic fertilizer on growth and yield of sweet potato.Santhi and Selvakumari (2000) have proposed that the addition of organic manure sources to chemical fertilizer could increase the yield of crops through improving soil productivity and higher fertilizer use efficiency.

Marketable Root yield

The results of the effect of integrated nutrient management on the marketable root yield of orange fleshed sweetpotato are presented in table 4. The interaction of composite manure and mineral fertilizer significantly ($p<0.05$) improved the marketable root yield of orange fleshed sweet potato relative to the control. The highest marketable root yield of 13.97t/ha was obtained with the application of 4t/ha composite manure +400kg NPK. The improved marketable root yield obtained with the combination of composite manure and mineral fertilizer could be as a result of improved soil physicochemical properties leading to the release of nutrients for the uptake by the sweet potato. The result is in line with similar results by Yeng *et al,* (2012) who obtained higher marketable root yield of sweet potato with integrated application chicken manure and inorganic manure. Hartemink, (2003) reported poultry manure in combination with mineral fertilizer increased the marketable root yield of sweetpotato.

Effect of Integrated Nutrient Management on β-carotene content of Orange fleshed Sweetpotato

The result of the effect of integrated nutrient management on the β-carotene content of orange fleshed sweet potato is presented in table 5. The result showed that the application of organic manure singly and its combination with NPK significantly ($p<0.05$) increased the β-carotene content of orange fleshed sweet potato. The β-carotene content of the orangefleshed sweetpotato increased generally with increase in the nutrient combinations. The highest carotenoid content of 733.2 ug/g was obtained with the application of 200kg/ha NPK with 8t/ha of composite manure. Application of composite manure singly at 8t/ha gave a β-carotene content of 726.6 ug/g. The increase in the carotenoid content might be due to increased soil fertilization and improvement in most soil chemical properties. Similar results were reported by Gichuhi *et al,* (2013) with application of different rates of broiler litter on Beauregard sweet potato; Moumouni *et al*, (2013) with application of organic and mineral fertilizers on antioxidants, polyphenolic and carotenoid contents of orange fleshed sweet potato; Neduchezhiyan *et al*, (2010) with application of farmyard manure in sweet potato; In addition kipkosgei *et al,* (2003) observed that the rate of increase in β-carotene content of sweetpotato depends on the type and the level of fertilizer applied. Nedunchezhiyan *et al,* (2010) noted that β-carotene content of sweetpotato though governed by the genetic factor, agronomic factors like source and quantity of nutrients significantly influenced the content. Also the increase in the carotenoid content of the orange fleshed sweetpotato might be as a result of improvements in the total nitrogen contents of the soil. Ukom *et al.*, (2009) reported that N fertilizer application significantly increased the carotenoid and crude protein content of sweetpotato with increasing N application up to 120 Kg/ha. This indicates that nitrogen stimulates carotene biosynthesis as reported by Voswai *et al.*, (2015) and thus agreeing with the findings of Constantin *et al,* (1984) and Ukom *et al.*, (2011)

Relationship between selected soil chemical properties and β-carotene content of orange fleshed sweetpotato

Total Nitrogen

The coefficient of total nitrogen is 185.8018 but is not statistically significant at ($p<0.05$).The result indicates that total nitrogen is a significant factor in determining the β-carotene content of orangefleshed sweetpotato (OFSP). The positive sign indicates that β-carotene content of OFSP increases with increase in nitrogen content of the soil i.e. a unit increase in the total nitrogen content of the soil leads to 185.8018 increase in the β-carotene content of OFSP .

Available Phosphorous

The coefficient of available phosphorous is 0 .600203 but is not statistically significant at ($p<0.05$).The result indicates that available phosphorous is a significant factor in determining the β-carotene content of orangefleshed sweetpotato. The positive sign indicates that β-carotene content of OFSP increases with increase in available phosphorous content of the soil i.e. a unit increase in the available phosphorous content of the soil leads to 0 .600203 increase in the β-carotene content of OFSP .

pH

The coefficient of pH is -32.84948 and is statistically significant at ($P < 0.05$). The result implies that pH is not a significant factor in determining the β-carotene content of OFSP. The negative sign on the coefficient tells that a unit increase in the pH leads to a decrease in the β-carotene of OFSP. I.e. a unit increase in soil pH leads to -32.84948 decrease in the β-carotene content of OFSP.

Calcium

The coefficient of Ca is -85.58 and is statistically significant at ($P < 0.05$).. The result implies that Ca is not a significant factor in determining the β-carotene content of OFSP. The negative sign on the coefficient tells that a unit increase in the Ca leads to a -85.58 decrease in the β-carotene of OFSP.

Percentage base saturation

The coefficient BS is -3.9873 and is statistically significant ($P < 0.05$). The result implies that BS is a significant factor in determining the β-carotene content of orangefleshed sweetpotato . The positive sign on the coefficient implies that β-carotene content in OFSP increase with increase in BS i.e. a unit increase in the BS leads to -3.9873 increase in β-carotene

Magnessium

The coefficient of Mg is -38.84241 and is not statistically significant at ($P < 0.05$). The result implies that Mg is not a significant factor in determining the β-carotene content of OFSP. The negative sign on the coefficient tells that a unit increase in the Mg content of the soil leads to a -38.84241 decrease in the β-carotene of OFSP.

Potassium

The coefficient of potassium is -357.2078 and is not statistically significant at ($P < 0.05$).. The result implies that potassium is not a significant factor in determining the β-carotene content of OFSP. The negative sign on the coefficient tells that a unit increase in the potassium content of the soil leads to a -357.2078 decrease in the β-carotene of OFSP.

Sodium

The coefficient of sodium is -4.765053 and is not statistically significant at ($P < 0.05$).. The result implies that sodium is not a significant factor in determining the β-carotene content of OFSP. The negative sign on the coefficient tells that a unit increase in the sodium content of the soil leads to a -4.765053 decrease in the β-carotene of OFSP.

Organic matter

The coefficient of organic matter is 37.38879 and is statistically significant at ($p<0.05$).The result indicates that organic matter is a significant factor in determining the β-carotene content of orangefleshed sweetpotato. The positive sign indicates that β-carotene content of OFSP increases with increase in organic matter content of the soil i.e. a unit increase in the organic matter content of the soil leads to 37.38879 increases in the β-carotene content of OFSP.

Effective Cation Exchange Capacity (ECEC)

The coefficient ECEC is 97.49538 and is statistically significant at ($p<0.05$).The result indicates that ECEC is a significant factor in determining the β-carotene content of orangefleshed sweetpotato. The positive sign indicates that β-carotene content of OFSP increases with increase in ECEC content of the soil i.e. a unit increase in the ECEC content of the soil leads to 97.49538 increase in the β-carotene content of OFSP.

Exchangeable Acidity (EA)

The coefficient of EA is -1.223778 and is not statistically significant at ($P < 0.05$).. The result implies that EA is not a significant factor in determining the β-carotene content of OFSP. The negative sign on the coefficient tells that a unit increase in the EA content of the soil leads to a -1.223778 decrease in the β-carotene of OFSP.

Conclusions and Recommendations

This study showed that integrated nutrient management (combining organic and mineral fertilizers) holds the key to improving the root yield as well as the β-carotenoid content of orange fleshed sweet potato. Combined application of composite manure and mineral fertilizer significantly ($p<0.05$) increased both the total and marketable root yield of orange fleshed sweet potato. Composite manure and its combination with mineral fertilizer significantly increased the β-carotene content with application of 8t/ha composite manure + 200kg/ha NPK giving the highest carotenoid content of 733.2µg/g. Results of the regression analysis showed that Organic matter, total nitrogen, available phosphorous, effective cation exchange capacity and percentage base saturation are some of the major soil chemical properties that contributes to increase in the β-carotene content of the orange fleshed sweetpotato. The carotenoid content of the orange fleshed sweetpotato increased generally with increasing rate of the treatments especially with composite manure indicating that the carotenoid content of orange fleshed sweetpotato can be improved with organic manure sources. Based on the above finding, orange fleshed sweetpotato production in the study area can be improved by combining the available animal manure sources such as cow dung, swine waste and poultry manure with mineral fertilizer. This will help in a big way to improve the soil properties and hence increase both sweetpotato yield and β-carotene content. Therefore; Application of 4t/ha composite manure + 400kg/ha NPK or 4t/ha composite manure is recommended for good root yield of orange fleshed sweetpotato in this area. For improved carotenoid content application of 8t/ha composite manure +200kg/ha mineral fertilizer or 6t/ha composite manure is recommended. Also the soil organic matter base should be improved upon by the application of organic manure or combined application of organic manure and mineral fertilizer.

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Table 1: Properties of the soil of the experimental sites.

Soil properties	2014 planting season	2015 planting season
Sand (%)	79.60	58.40
Silt (%)	6.40	12.80
Clay (%)	14.00	28.80
Textural class	Sandy loam	Sandy Clay loam
Soil pH (H_20)	4.2	4.8
Soil pH(KCL)	3.7	3.6
Organic carbon (%)	1.04	0.94
Organic matter (%)	1.79	1.62
Total nitrogen (%)	0.028	0.098
Available phosphorous(mg/kg)	10.6	54.3
Exchangeable acidity (Cmol/kg)	1.40	1.92
Calcium (Cmol/kg)	3.20	1.60
Potassium (Cmol/kg)	0.043	0.078
Magnesium (Cmol/kg)	0.80	0.80
Sodium (Cmol/kg)	0.092	0.242
ECEC (Cmol/kg)	5.54	4.64
Base saturation (Cmol/kg)	74.72	58.62

Table 2 : Chemical properties of the composite manure used for the study

Chemical properties	Value
pH(H_2O)	10.5
N (%)	5.39
P (%)	3.28
K (%)	3.68
Ca (%)	2.67
Mg(%)	1.95
Na(%)	2.33
OC (%)	3.00
OM (%)	5.17

Table 3: Effect of Integrated Nutrient Management on the total root yield orange fleshed sweet potato (t/ha)

NPK(kg/ha)	0	2	4	6	8	Mean
0	7.83	11.37	13.17	11.67	10.70	10.93
200	8.30	12.07	13.13	12.37	12.27	11.63
400	11.53	13.73	15.90	9.93	12.00	12.62
600	14.93	10.47	9.13	13.13	14.83	12.50
Mean	10.65	11.91	12.83	11.78	12.45	

LSD (0.05) organic manure=N.S
LSD (0.05) NPK=N.S
LSD (0.05)0rganic manure x NPK=4.387

Table 4: Effect of Integrated Nutrient Management on the total root yield orange fleshed sweet potato (t/ha)

NPK(kg/ha)	0	2	4	6	8	Mean
0	6.90	9.43	11.70	9.10	8.93	9.21
200	7.43	9.70	11.60	10.70	10.27	9.94
400	11.07	12.97	13.97	7.57	10.00	11.11
600	13.90	8.93	7.83	11.20	12.67	10.91
Mean	9.82	10.26	11.27	9.64	10.47	

LSD (0.05) Composite manure = N.S
LSD (0.05) NPK = N.S
LSD (0.05) Composite manure X NPK = 4.375

Table 5: **Effect of Integrated Nutrient Management on the β-carotene content of orange fleshed sweet potato (μg/100g)**

NPK(kg/ha)	0	2	4	6	8	Mean
0	566.9	619.4	636.0	696.6	726.6	649.1
200	468.5	583.9	656.8	702.2	733.2	628.9
400	595.6	519.4	612.1	679.0	705.0	622.2
600	639.8	490.8	602.6	628.5	681.1	608.6
Mean	567.7	553.4	626.9	676.6	711.5	

LSD (0.05) Composite manure = 37.89
LSD (0.05) NPK = N.S
LSD (0.05) Composite manure X NPK = 75.78

Table 6: **Regression analysis for the determinants of β-carotene content of orange fleshed sweetpotato**

Variables	Coefficient	standard Error	t-value	Probability
%Bs	3.987379	2.030011	1.96	0.055
ECEC	97.49538	36.46899	2.67	0.010
EA	-1.223778	60.27266	-0.02	0.984
OM	37.38879	15.91323	2.35	0.023
Na	-4.765053	275.0199	-0.02	0.986
K	-357.2078	395.3301	-0.90	0.371
Mg	-38.84241	25.23736	-1.54	0.130
Ca	-85.58447	37.9008	-2.26	0.029
pH	-32.84948	27.2635	-1.20	0.234
Av. P	.600203	.7506419	0.80	0.428
Total N	185.8018	269.5834	0.69	0.494
Constant	97.04309	248.6189	0.39	0.698